This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

QC
1
U582s
NO.71

B 1,063,780

DEPARTMENT OF COMMERCE AND LABO
BUREAU OF STANDARDS
S. W. STRATTON, Director

THE ELECTRODE EQUILIBRIUM OF STANDARD CELL

BY

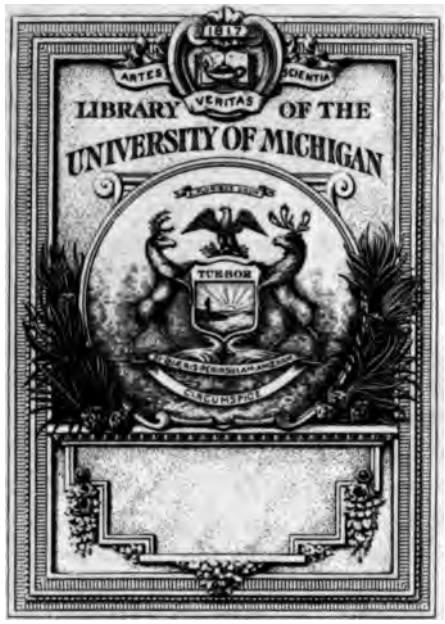
F. A. WOLFF, Associate Physicist
and
C. E. WATERS, Assistant Chemist
Bureau of Standards

[OCTOBER 4, 1907]

REPRINT NO. 71

(FROM BULLETIN OF THE BUREAU OF STANDARDS, VOL. 4

WASHINGTON
GOVERNMENT PRINTING OFFICE
1907


1817
ARTES
SCIENTIA
VERITAS
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
TUEBOR

385

DEPARTMENT OF COMMERCE AND LABOR
BUREAU OF STANDARDS
S. W. STRATTON, Director

THE ELECTRODE EQUILIBRIUM OF THE STANDARD CELL

BY

F. A. WOLFF, Associate Physicist

and

C. E. WATERS, Assistant Chemist

Bureau of Standards

[OCTOBER 4, 1907]

REPRINT NO. 71

(FROM BULLETIN OF THE BUREAU OF STANDARDS, VOL. 4, NO. 1)

WASHINGTON
GOVERNMENT PRINTING OFFICE
1907

THE ELECTRODE EQUILIBRIUM OF T

F. A. Wolff and C. E. W

Some experiments described by Hulett[2] of a state of unstable equilibrium in tl account of the importance of the subject, the question at the Bureau of Standards.

The equilibrium between cadmium an phate was first studied. Saturated solution up in air, nitrogen, hydrogen, and *in vacu* but in no case did the electromotive forc treated and untreated solutions differ more though the samples shaken in the presence from the formation of an excess of basic c

The equilibrium of the system mercury mium sulphate, and of the corresponding was then studied in special cells, so co materials could be rotated and the effect ing the cell.

This consisted of a tube about 2 cm in provided at the lower end with a small bu wire was sealed. The bulb was connecte narrow neck, so that, with sufficient mer num terminal was not in contact with rotation.

[1] An abstract of this paper was read at the New Physical Society, December, 1906, Phys. Rev., **24**, 2

[2] Phys. Rev., **23**, 166; 1906.

A shorter internal tube about 1 cm in diameter with several lateral openings, sealed in at the other end of the main tube, was charged with amalgam and crystals of cadmium or zinc sulphate, which were held in place by a plug of asbestos. Contact with the amalgam was made by means of a platinum wire, protected from the solution by sealing it into a glass tube, which extended through the upper seal made after the introduction of the above materials.

The mercurous sulphate and cadmium sulphate or zinc sulphate crystals were introduced over the mercury through a side tube by which the cell was exhausted and through which a saturated solution of cadmium or zinc sulphate was subsequently introduced. After filling, the side tube was sealed off, leaving only a small air bubble in the cell, thus practically eliminating any possible influence of air.

The cells were then placed in holders so arranged that one dozen could be simultaneously rotated at any desired speed, with their axes parallel to the axis of rotation and inclined at a small angle to the horizontal, thus insuring a thorough stirring of the paste and mercury with the electrolyte, even at five or six revolutions per minute. The measurements were made in an automatically controlled oil bath at 25°, immediately after stopping the rotation and raising the holder to a vertical position under the oil. Altogether 12 Weston and 5 Clark cells of this type were set up with samples of mercurous sulphate, made not only by the electrolytic method but also by several chemical methods. The mercurous sulphate was washed in a Gooch crucible three times with 1 : 6 sulphuric acid, six times with absolute alcohol, and three times with saturated zinc or cadmium sulphate solution. The data and results are given in the following tables:

TABLE I.

Weston Rotating C

Cell	Date 1906	$CdSO_4$	Cd Amalg.	Mercury	Samp	
R 1	Oct. 13	Purified by Recrystallization.	12½ % Kahl. El. Dist.	Distilled at reduced pressure.	b_{13}	
*R 11	Oct. 30	"	"	"	b_{13}	
†R 12	Oct. 30	"	"	"	b_{13}	
R 3	Oct. 13	"	"	"	e_2	
R 5	Oct. 16	"	"	"	d_2	
R 6	Oct. 16	"	"	"	c	
R 2	Oct. 13	"	"	"	a_{12}	W
‡R 8	Oct. 30	"	"	"	a_{12}	W
R 4	Oct. 16	"	"	"	a_9	W
‡R 10	Oct. 30	"	"	"	a_9	W
R 7	Oct. 16	"	"	"	i_2	W
‡R 9	Oct. 30	"	"	"	i_2	W

* Platinum terminal exposed to paste.

† Basic cadmium sulphate added to paste.

‡ Mercurous sulphate rotated with saturated $CdSO_4$ solut the cells.

TABLE II.

Clark Rotating Ce

Cell	Date 1906	$ZnSO_4$	Zn Amalg.	Mercury	Sa
R 2	Nov. 5	Purified by Electrolysis	Kahl. I	Distilled at reduced pressure	b_{16}
*R 3	Nov. 5	"	"	"	$_{16}b$
R 5	Nov. 5	"	"	"	a_{12}
*R 4	Nov. 5	"	"	"	a_{12}
R 1	Nov. 5	"	"	"	a_9

* Zinc oxide added to ps

TABLE III.

Weston Rotation Cells.

[Differences in microvolts from mean of reference cells.]

Date	R1		R11		R12		R3		R5		R6	
	Diff.	Time	Diff.	Time	Diff.	Time	Diff.	Time	Diff.	Time	Diff.	Time
		D. H.		D. H.		D. H.		D. H.		D. H.		D. H.
Oct. 18,'06	+72	0	.....	.....	.....	.....	+89	0	+ 83	0	+92	0
" 19	+43	0	.....	.....	.....	.....	+59	0	+ 59	0	+67	0
" 20	+11	0	.....	.....	.....	.....	+24	0	+ 34	0	+39	0
" 22	+29	0	.....	.....	.....	.....	+39	0	+ 54	0	+55	0
" 23	+44	15	.....	.....	.....	.....	+53	15	+ 57	15	+66	15
" 24	+42	18	.....	.....	.....	.....	+57	18	+ 88	18	+43	18
" 25	+45	1 9	.....	.....	.....	.....	+41	1 9	+103	1 9	+41	1 9
" 27	+63	3 1	.....	.....	.....	.....	+64	3 1	+142	3 1	+58	3 1
" 29	+88	5 1	.....	.....	.....	.....	+88	5 1	+149	5 1	+83	5 1
" 31	+61	6 21	− 4	0	−11	0	+69	6 21	+ 93	6 21	+56	6 21
Nov. 5	+73	10 14	+ 55	3 7	+37	3 7	+83	10 14	+ 90	10 14	+65	10 14
" 8	+66	12 17	+ 79	5 11	−17	5 11	+67	12 17	+104	12 17	+46	12 17
" 12	+72	16 12	+ 69	9 0	−31	9 6	+69	16 12	+ 71	16 12	+52	16 12
" 16	+64	20 8	+ 116	12 20	−54	13 2	+70	20 8	+ 50	20 8	+55	20 8
" 19	+59	23 5	+ 139	15 17	−36	15 23	+69	23 5	+ 47	23 5	+54	23 5
" 24	+50	28 4	+ 204	20 16	−26	20 22	+71	28 4	+ 41	28 4	+54	28 4
" 30	+35	28 8	+ 117	20 20	−37	21 2	+35	28 8	+ 29	28 8	+32	28 8
Dec. 5	+31	28 8	+ 93	20 20	−39	21 2	+33	28 8	+ 26	28 8	+30	28 8
" 10	+46	32 1	+ 240	24 13	− 8	24 19	+74	32 1	+ 40	32 1	+54	32 1
" 14	+50	35 16	+ 271	28 4	−25	28 10	+74	35 16	+ 45	35 16	+53	35 16
" 21	.....	.....	+ 348	33 21	−17	34 12	+92	41 18	+ 41	41 18	+38	41 18
Jan. 5,'07	.....	.....	+ 520	46 12	−32	47 3	+67	54 7	+ 41	54 7	+19	54 7
" 10	.....	.....	+ 567	50 6	−27	51 20	+66	59 4	+ 47	59 4	+28	59 4
" 14	.....	.....	+ 427	52 18	−34	54 8	+51	61 16	+ 40	61 16	+13	61 16
" 24	.....	.....	+ 749	61 12	−26	62 16	+66	70 0	+ 46	70 0	+33	70 0
" 30	.....	.....	+ 926	67 2	−36	68 6	+50	75 22	+ 42	75 22	+24	75 22
Feb. 5	.....	.....	+1030	71 10	−36	73 6	+49	80 21	+ 37	80 21	+32	80 21
" 8	.....	.....	+1073	72 21	−35	74 18	+46	82 9	+ 38	82 9	+28	82 9
Mar. 1	.....	.....	.....	.....	−43	93 14	−38	101 5	+ 38	101 5	+35	101 5
" 12	.....	.....	.....	.....	−42	102 14	−29	110 5	+ 32	110 5	+40	110 5
Apr. 5	.....	.....	.....	.....	−41	121 4	− 8	128 19	+ 90	128 19	+51	128 19
" 10	.....	.....	.....	.....	−34	124 10	−10	132 1	+ 94	132 1	+76	132 1
May 25	.....	.....	.....	.....	−38	135 4	− 7	142 19	+127	142 19	+84	142 19
June 4	.....	.....	.....	.....	−34	144 20	− 3	152 11	+135	152 11	+95	152 11
" 7	.....	.....	.....	.....	−37	147 18	+ 2	155 9	+142	155 9	+94	155 9
" 15	.....	.....	.....	.....	−37	155 6	− 3	162 21	+169	162 21	+99	162 21
Aug. 15	.....	.....	+ 494	72 21	−40	155 6	− 5	162 21	+ 44	162 21	+43	162 21
Sept. 27	.....	.....	+ 571	72 21	−41	155 6	− 6	162 21	+ 38	162 21	+23	162 21

TABLE III.

Weston Rotation Cells.

[Differences in microvolts from mean of refer

R 2		R 8		R 4		R 10	
Diff.	Time	Diff.	Time	Diff.	Time	Diff.	Time
	D. H.		D. H.		D. H.		D. H.
+148	0	.....	.....	+ 137	0	.....	.....
+115	0	.....	.....	+ 100	0	.....	.....
+ 59	0	.....	.....	+ 69	0	.....	.....
+ 98	0	.....	.....	+ 94	0	.....	.....
+103	15	.....	.....	+ 95	15	.....	.....
+220	18	.....	.....	+ 252	18	.....	.....
+275	1 9	.....	.....	+ 354	1 9	.....	.....
+245	3 1	.....	.....	+ 316	3 1	.....	.....
+313	5 1	.....	.....	+ 363	5 1	.....	.....
+321	6 21	− 9	0	+ 441	6 21	+216	0
+340	10 14	+515	3 7	+ 440	10 14	+590	3 7
+329	12 17	+474	5 11	+ 572	12 17	+556	5 11
+292	16 12	+389	9 0	+ 429	16 12	+501	9 0
+279	20 8	+380	12 20	+ 810	20 8	+440	12 20
+259	23 5	+414	15 17	+ 754	23 5	+479	15 17
+237	28 4	+364	20 16	+ 754	28 4	+389	20 16
+152	28 8	+272	20 20	+ 655	28 8	+265	20 20
+136	28 8	+228	20 20	+ 613	28 8	+234	20 20
+204	32 1	+337	24 13	+ 931	32 1	+336	24 13
+194	35 16	+336	28 4	+1092	35 16	+314	28 4
+191	41 18	.....	.....	.....	.....	+248	33 21
+150	54 7	.....	.....	.....	.....	+207	46 12
+147	59 4	.....	.....	.....	.....	+207	50 6
+126	61 16	.....	.....	.....	.....	+195	52 18
+ 56	70	.....	.....	.....	.....	+196	61 12
+110	75 22	.....	.....	.....	.....	+146	67 2
+115	80 21	.....	.....	.....	.....	+135	71 10
+113	82 9	.....	.....	.....	.....	+139	72 21
+118	101 5	.....	.....	.....	.....	.....	.....
+ 60	110 5	.....	.....	.....	.....	.....	.....
+115	128 19	.....	.....	.....	.....	.....	.....
+114	132 1	.....	.....	.....	.....	.....	.....
+113	142 19	.....	.....	.....	.....	.....	.....
+115	152 11	.....	.....	.....	.....	.....	.....
+111	155 9	.....	.....	.....	.....	.....	.....
+135	162 21	.....	.....	.....	.....	.....	.....
+ 15	162 21	.....	.....	.....	.....	+ 55	72 21
+ 7	162 21	.....	.....	.....	.....	+ 55	72 21

TABLE IV.

Clark Rotation Cells.

[Differences in microvolts from mean of reference cells.]

Date	R 2		R 3		R 5		R 4		R 1	
	Diff.	Time	Diff.	Time	Diff.	Time	Diff.	Time	Diff.	Time
		D. H.		D. H.		D. H.		D. H.		D. H.
Nov. 6,'06	−25	0	−120	0	0	0	−140	0	+ 13	0
Nov. 7	−13	22	−130	22	+ 30	22	− 50	22	+ 27	22
Nov. 8	+16	1 22	− 54	1 22	+ 59	1 22	− 26	1 22	+ 49	1 22
Nov. 12	+16	4 16	+ 45	4 16	+100	4 16	+ 25	4 16	+ 90	4 16
Nov. 16	+17	8 13	+ 2	8 13	+ 89	8 13	+ 2	8 13	+ 72	8 13
Nov. 24	+21	16 9	+ 4	16 9	+ 89	16 9	± 0	16 9	+ 81	16 9
Nov. 30	+36	16 12	+ 18	16 12	+ 61	16 12	− 5	16 12	+ 46	16 12
Dec. 5	+22	16 12	− 20	16 12	+ 45	16 12	− 43	16 12	+ 22	16 12
Dec. 10	+22	20 6	+202	20 6	+ 72	20 6	− 34	20 6	+ 22	20 6
Dec. 14	+21	23 20	+273	23 20	+113	23 20	+ 98	23 20	+ 8	23 20
Dec. 21	+26	29 22	+ 22	29 22	+ 34	29 22	+ 20	29 22	− 36	29 22
Jan. 5,'07	.....	.....	−217	42 14	−136	42 14	− 17	42 14	+ 12	42 14
Jan. 10	.....	.....	−243	47 10	−141	47 10	− 3	47 10	+ 7	47 10
Jan. 14	.....	.....	−160	49 22	−199	49 22	− 50	49 22	− 99	49 22
Jan. 24	.....	.....	+ 5	58 7	− 5	58 7	− 47	58 7	+157	58 7
Jan. 30	.....	.....	+ 20	64 4	−159	64 4	− 35	64 4	− 33	64 4
Feb. 5	.....	.....	+ 16	69 4	−155	69 4	− 26	69 4	− 48	69 4
Feb. 8	.....	.....	+ 17	70 16	−145	70 16	− 23	70 16	− 4	70 16
Mar. 1	.....	.....	− 17	89 12	−143	89 12	− 37	89 12	− 97	89 12
Mar. 12	.....	.....	− 20	98 12	−182	98 12	− 60	98 12	−227	98 12
Apr. 5	.....	.....	− 88	117 2	− 68	117 2	− 28	117 2	−108	117 2
Apr. 10	.....	.....	− 91	120 8	− 59	120 8	− 43	120 8	−145	120 8
May 25	.....	.....	.....	.....	− 76	131 2	− 79	131 2	+174	131 2
June 4	.....	.....	.....	.....	− 91	140 18	− 84	140 18	−216	140 18
June 7	.....	.....	− 47	143 16	− 79	143 16	− 62	143 16	.....	.....
June 15	.....	.....	.....	.....	− 86	151 4	− 76	151 4	+ 3	151 4